CITY OF THE VILLAGE OF CLARKSTON

Historic District Commission

Art Pappas Village Hall 375 Depot Road
Clarkston, MI 48346

Notice of Denial
August 15, 2025

Plans for:	20-26 South Main Street
Owner:	Sarah Schneider
Applicant:	Sarah Schneider

At the Clarkston Historic District Commission (HDC) meeting held on August 12, 2025, the Commissioners reviewed the original application dated January 31, 2025, which was extended in accordance with the wishes of Ms. Schneider. Two Certificates of Appropriateness have been approved dealing with portions of this complex multi-partite application. The owner has not been able to finalize her plans for the corner entrances with her design team. Ms. Schneider plans to submit a new application when these plans are ready. Therefore, the HDC issues a denial for the remaining parts of the original application.

In accordance with the City of the Village of Clarkston Ordinance No. 118, Section 10.01, the applicant has the rights of appeal to the State Historic Preservation Review Board and to the Circuit Court in response to this denial.

The HDC welcomes a new application for this property at your convenience.

Michael Moon, Secretary
Clarkston Historic District Commission
375 Depot Road
Clarkston, Michigan 48346
248-376-4076

Clarkston Historic District Historic Commission

Observation Report

for

22 South Main Street



Historical Name John Hertwig's Inn

Prepared by Department of

OAKLAND COUNTY MICHIGAN
ECONOMIC DEVELOPMENT
DAVID COULTER
OAKLAND COUNTY EXECUTIVE

April 28, 2025

INDEX

Introduction 1

Executive Summary ..... 2 - 4

Physical Conditions and Treatment Opinion ..... 5 – 8

Appendix
Preservation Brief #16

Prepared by
Ronald R, Campbell, AIA
Principal Planner / Preservation Architect
36 CFR Part 61
Federally Qualified in Historic Architecture
Oakland County Economic Development
Planning and Local Business Development

On February 19,2025, the Clarkston Historic District Commission contacted Main Street Oakland County (MSOC) inquiring about design assistance regarding an application before the Commission. On March 3rd, the HDC confirmed the request to review the applicant's proposed work which includes:

(1) remove all current siding (believed by the owner to be a combination of aluminum siding, vinyl and wood; our information is the aluminum siding was removed in the 1970s, replaced with wood clapboard) and replace with Hardie board;
(2) replace/rebuild all porches (decking and trim) with composite material;
(3) remove all wood columns and replace with composite material;
(4) remove existing "trim" and replace with unspecified material "as needed"*; The proposed plans indicate that the trim would remain and be repaired*
(5) repair entry gables (entablatures at corner entries?) and paint;
(6) add canvas awnings over first floor windows and center entry doors; *The proposed plans indicate that canvas awnings would only be at the windows on the first floor.*
(7) remove and replace all entry doors.

On March 11th Ron Campbell Design Architect from Main Street Oakland County met on site with Rob Hauxwell, HDC Chair and HDC Commissioner Dr. Michael Moon. Observations were made around the entire perimeter at pedestrian level. The review was made in a non-destructive method, preserving the finish materials in place. The observations included:

1. Testing the stability/resistance of the wood (Pick Test);
2. Observing cracking, warping, splitting or loss of material and to what extent;
3. Observing for any visible decay, mildew or fungus growth;
4. Signs of physical damage, insect, animal or human caused;
5. Condition of the finished surfaces.

This report also notes items such as Universal Design practices which the owner should be made aware of, and comments on historic preservation measures pertinent to the Commission's review.

An Executive Summary follows with more detailed information, photos and opinions following the summary.

EXECUTIVE SUMMARY

The proposed modifications involve the oldest commercial building in Clarkston's commercial district. Originally constructed in 1842 it was expanded in 1882 with the relocation of another building in town to form the footprint that is there today.

Remove and Replace Siding

The current siding is not the original siding and is believed to have been resided in the 1970s. The siding is in good to fair condition. Approximately ½ of the building has aluminum siding over what is believed to be the wood siding. The structure underneath the aluminum siding was not observed. It is my opinion that the owner be allowed to remove the aluminum siding, taking care not to harm the underlayment. This would allow for further review of the conditions and suggestions based on that review. It may show that the aluminum siding on the south end portion of the east elevation was covered because it was in worse condition that the wood siding which remained exposed.

Observations and a pick test of the wood siding found it to be strong, rot free wood. Cracks and paint blistering and pealing was minimal. Discoloration in the paint finish was observed in several locations. It could be caused by the presence of water or tannin bleeding of the wood. Workmanship in the previous installation and in some of the repairs is questionable. The face nailing using non-galvanized nails has led to corrosion and would require their removal and replacement with Stainless Steel or Hot Dipped galvanized nails if the present siding is to remain. If replacement siding is allowed it is recommended that stainless steel or hot dipped galvanized nails be used. Some sections of the existing siding it will be necessary to replace. If the wood siding is to remain, the replacement siding should be of like wood. If the owner wanted to install new wood siding, I would recommend Accoya, Cypress, Redwood or Cedar.

The proposed replacement siding is fiber cement board, composed of cement, sand and cellulous fibers. It has been used on historic structures. Its visual appearance is nearly identical to the wood clapboard currently on the building. I have found it to be somewhat susceptible when it comes in contact with sodium chloride (salt). An alternate material to wood and the fiber cement board is an engineered wood composite. It's created by combining wood strands or fibers with adhesive binders. It is designed to replicate traditional wood siding, and has been acceptable for use on historic structures.

Part of the HDC discussion and decision-making process will need to address the fact that the current siding is not the original and will removing the current siding and installing new damage any historic material. As building materials of the past have lost much of the characteristics that provided strength and sustainability discussions in the preservation field have occurred . A copy of Preservation Briefs on substitute materials is provided in the Appendix.

EXECUTIVE SUMMARY cont.

Remove and Replace Porches including the columns

The porches are a safety hazard and need to be rebuilt. The proposed treatment is in accordance with the Secretary of the Interior Guidelines. There is opportunity to reconstruct the porches based on the plans from 1882. The plans submitted indicate that the corner porches were "original to the building" but photographic evidence disputes that. There is opportunity that the original entrances on the north and south could be restored. This is beyond the scope of work currently being proposed but if made aware it might be agreeable. The reconstruction of the two other porches to historic accuracy is possible with the partial image of the corner of one of these porches in an early photo.

A couple of major issues need to be resolved. Handrails and guardrails meeting current building code will be required and needs to be shown in the plans and on the elevation. The finish should also be provided. The major issue to be resolved is Barrier Free Accessibility. It will be up to the Building Official to determine if the scope of work is maintenance. If the Official determines it is more than maintenance, then the Michigan Barrier Free Code will have to be designed for.

Regardless of the Building Official, American Disability Act (ADA) has required all existing buildings to meet the ADA Design Standards to the extent of feasibility. By not providing accessibility the owner is subject to a discrimination lawsuit filed by anyone denied access. Since the Building Code and ADA involve similar requirements, it would be an appropriate time to comply with both. Incorporating such measures may or may not impact the historic character of the façade depending on the design. It is an issue that should be resolved as soon as possible to be brought into the construction process.

Existing trim is to be repaired as needed and painted

It is important to know the material with which the trim will be repaired. Introducing a different material with different expansion/contraction rates can physically damage the structure and be a burden on the owner. Leaving the wood trim in place will have a different expansion and contraction rate than any substitute siding other than wood. This could cause a maintenance issue for the owner in the future due to separation and failure of the caulking. Separation of materials and caulking failure will allow water penetration into the wall. So, it is ideal to use the same material for siding and trim. In which case it will be critical to make sure all of the trim sizes remain as they are currently or it will impact the visual appearance. The method of repair would be helpful in determining the appearance of the finish work and its sustainability.

EXECUTIVE SUMMARY cont.

Add Canvas Awnings Over the First - Floor Windows

There is no evidence that the building ever had awnings as described. The Secretary of the Interior Standards for Rehabilitation generally discourages adding awnings at windows that never had them and more so to building types that generally didn't have them. Adding them could greatly alter the building's visual character without historic context or evidence.

Replace all the Entry Doors

It appears on the submittal that the entry doors being referred to are the ones on the west elevation. These doors are not original, and the proposed match is identical to the existing. The door on the north elevation does not appear to be an entry door but is original or nearly original. Consideration should be taken to repair the bottom rail of this door, which is in a stage of rot, in accordance with the Secretary of the Interior Guidelines, to preserve it. The sill, door trim and adjacent wall area also shows signs of rot and should be addressed.





Proposed Treatment of Current Siding:

Scope of the proposed work consists of removing and replacing the wood lap siding with fiber cement lap board siding. Final finish to be determined.

Physical Condition and Treatment Opinion:

A combination of wood and aluminum siding believed to overlay wood clapboard was found. Wood Clapboard is present on the North and west elevations. Aluminum clapboard style siding is covering what is believed to be wood clapboard on the south and approximately ¾'s of the east elevation. The remaining portion of the east elevation is wood.

An awl was used to test the stability and resistance of the wood primarily on the three lowest boards at various locations. The hand pressure on the awl was met with considerable resistance, never allowing the awe to penetrate more than 3/32" – 1/8", indicating strong rot free wood. Several of the boards were cracked or split, seemed to be the result of human intervention.



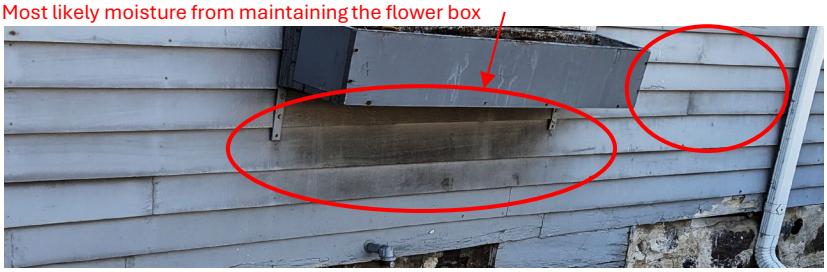




There was no appearance of decay but, discoloration is visible at several locations. The discoloration could be an indication of one of several issues, including moisture problems, mildew or tannin bleeding of the wood. There was little evidence of the paint bubbling and peeling, which would mean there is not a high level of moisture being present in the wood or being transmitted from within the building, except at the locations where the paint has failed and exposes the bare wood. The cause should be determined and corrected before repainting or replacement.



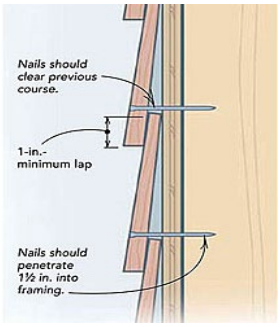
Most likely moisture from maintaining the flower box



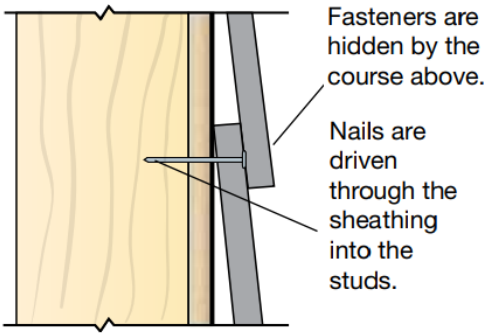
Physical Condition and Treatment Opinion: cont.

The current wood siding in my opinion was not installed correctly when using face nail method. Face nailing method results in the fastening nail head to be exposed. It appears the nails used were non-galvanized nails and are rusting. This can lead to rust stains, paint failure, loss of anchorage and wood rot as the corroding nails lead to water intrusion. To prevent these problems the proper nails to use are stainless steel or hot dipped galvanized. Face nailing can also lead to other problems if not properly installed. The Face nailing should clear the previous wood course to allow expansion and contraction to occur. Top and bottom nailing should be avoided.

Face Nailing



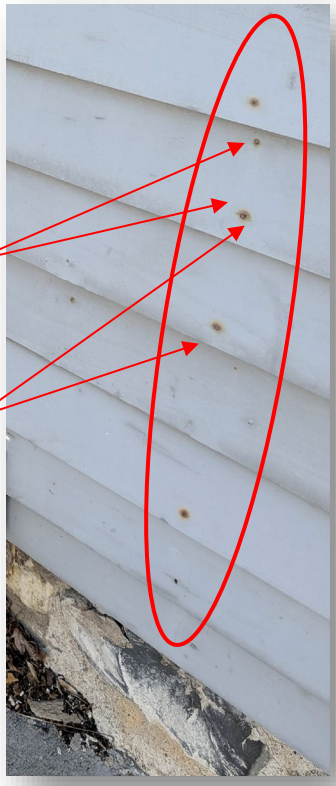
Blind Nailing



There are locations where the construction techniques and/or experience should be questioned, and for the repairs that have occurred. From random nails spacing to more than one nail in the same course could lead to future problems.



Possible repair nail randomly set at the middle of the course



Proposed treatment of Current Porches, Columns and Gable Repair
Scope of work includes the removal and reconstruction

Physical Condition and Treatment Opinion:

The porches are in very poor condition and present a safety hazard in their current condition. It is obvious they need to be removed and replaced. The proposed treatment is to reconstruct them and seems to be in accordance with the Secretary of the Interior Standards for Rehabilitation.





One thing the proposed plans don't mention or show but will be required by building code is handrails and guardrails. The code for the handrails hasn't changed much since the porches were built. But the height of guardrails has increased for the required height of 42". This should be shown on the plans so the impact it might have is clearly understood.

The other and more important thing is the need for Accessibility. There are two laws which require accessibility. The Building Code if the Building official deems this work to be more than maintenance and ADA which is a federal discrimination lawsuit waiting to happen. All existing buildings are required to meet ADA as much as is reasonable. With the scope of this work, it should be addressed in the design.

The proposed plans note that the corner porches are original to the building. But early photographs show that the corners were square at both ends and the entrance doors were aligned with the face of the building and further in from the corner. Additional research is required for the north porch/entrance. The photo, below, on the left provides good evidence of the original porches, which shows a shed roof and not a gable. It would be possible to recreate the original look if there was willingness to recreate them. The photo on the right shows the entrance on the west and a square corner.





Proposed treatment of Existing Trim

Physical Condition and Treatment Opinion:

The opinion of this proposed treatment is stated in the Executive Summary. See page 4.

Add Canvas Awnings Over the First - Floor Windows

Physical Condition and Treatment Opinion:

The opinion of this proposed treatment is stated in the Executive Summary. See page 5.

Replace all the Entry Doors

Physical Condition and Treatment Opinion:

The opinion of this proposed treatment is stated in the Executive Summary. See page 5.

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Ronald R, Campbell, AIA
Principal Planner / Preservation Architect
36 CFR Part 61
Federally Qualified in Historic Architecture
Oakland County Economic Development
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End

APPENDIX

16 PRESERVATION BRIEFS

The Use of Substitute Materials on Historic Building Exteriors

John Sandor, David Trayte, and Amy Elizabeth Uebel



National Park Service
U.S. Department of the Interior
Technical Preservation Services

The *Secretary of the Interior's Standards for Rehabilitation* generally require that deteriorated distinctive architectural features of a historic property be repaired rather than replaced. Standard 6 of the *Standards for Rehabilitation* further states that when replacement of a distinctive feature is necessary, the new feature must "match the old in composition, design, color, texture, and other visual properties, and, *where possible*, materials" (emphasis added). While the use of matching materials to replace historic ones is always preferred under the *Standards for Rehabilitation*, the Standards also purposely recognize that fexibility may sometimes be needed when it comes to new and replacement materials as part of a historic rehabilitation project. Substitute materials that closely match the visual and physical properties of historic materials can be successfully used on many rehabilitation projects in ways that are consistent with the Standards.

The fexibility inherent in the *Standards for Rehabilitation* must always be balanced with the preservation of the historic character and the historic integrity of a building, of which historic materials are an important aspect. Any replacement work reduces the historic integrity of a building to some degree, which can undermine the historic character of the property over time. With limited exceptions, replacement should only be considered when damage or deterioration is too severe to make repair feasible. When needed replacement is made with a material that matches the historic material, the impact on integrity can be minimal, especially when only a small amount of new material is needed. When a substitute material is used for the replacement, the loss in integrity can sometimes, although not always, be greater than that of a matching material. Also, whether historic or substitute material, there is a point where the amount of replacement can become excessive and the building's historic integrity is diminished to an unacceptable degree, regardless of the material used—that is, a loss of authenticity and the physical features and characteristics closely associated with the property's historic signifcance.

The term *substitute materials* is used to describe building materials that have the potential to match the appearance, physical properties, and related attributes of historic materials well enough to make them alternatives for use in current preservation practice when historic materials require replacement.

Compelling reasons to use a substitute material instead of the historic material include the unavailability or poor performance of the historic material, or environmental pressures or code-driven requirements that necessitate a change in material. When using a substitute material for replacement it is critical that it match the historic material in all of its visual and physical properties to preserve the historic character of the building and minimize the impact on its integrity.

Substitute materials can be cost-effective, permit the accurate visual duplication of historic materials, and provide improved durability. While the behavior of traditional, historic materials is generally well understood, the behavior of newer materials can be less established and sometimes less predictable. Substitute materials are most successful when the properties of both the original material and the substitute are thoroughly understood by all those involved in the design and construction process. The architect must be adept at the selection of substitute materials and their incorporation into architectural plans and specifcations. The contractor or tradesperson in the feld must also be experienced with their use.

This Preservation Brief provides general guidance on the use of substitute materials as replacement materials for distinctive features on the exterior of historic buildings. Due to the ever-evolving product market for construction materials, this Brief does not provide specifcations for substitute materials. This guidance should be used in conjunction with qualifed professionals who are knowledgeable in current construction and historic preservation practices.

This Brief includes a discussion of the appropriate use of substitute materials and provides a path for decision-making in their use. In considering the use of substitute materials, such issues as the deterioration or failure of the historic building component and material must be understood. The existing component's physical and visual properties, profle, surface texture, dimensions, and performance should be identifed to establish the basis for evaluating a possible replacement material. The physical and visual properties of the various substitute materials available should also be assessed and compared to the original material for their physical and visual compatibility. Lastly, the suitability of a given substitute replacement material should be determined based on how well the material matches both the physical and visual properties of the existing material as well as any specifc performance or application needs. The Brief's descriptions of common substitute materials are not meant to be comprehensive, and, as the performance history of newer materials continues to grow and new materials are developed, available options will change, and our understanding of current material performance will continue to evolve.

Historical Use of Substitute Materials

The tradition of using affordable and common materials in imitation of more expensive and less available materials is a long one. At Mount Vernon, for example, George Washington used wood painted with sand-impregnated paint to imitate rusticated stone. This technique, along with scoring stucco into block patterns, was common in Colonial America to imitate stone.

Nineteenth-century technology made a variety of materials readily available and widely used that were not only able to imitate traditional materials but were also cheaper to fabricate and easier to use. Traditionally, carved stone units were individually worked. Molded or cast materials greatly increased effciency in creating repetitive elements. Cement-based products such as cast stone could provide convincing imitations of natural stone with carefully chosen aggregates and cements and was typically a commercially manufactured product. It could be tooled like natural stone, though that could reduce much of the cost advantage. These carefully-crafted cementitious products were widely used as trim elements for masonry structures or as the face material for an entire building. At the other end of the spectrum, mail-order catalogs provided a wide variety of forms for molding concrete that were merely evocative of natural stone and did little to match its appearance. Concrete masonry units could be fabricated locally and on site, avoiding expensive quarrying and shipping costs.

Offering similar effciencies as cast stone for reproducing repetitive and even complex decorative shapes, terra cotta could mimic the surface characteristics of stone with various textures and glazes. It was popular in the late nineteenth and early twentieth centuries for details on stone or brick buildings as well as for the entire skin of large and elaborately detailed buildings.

Cast iron was also used to imitate stone, often with very decorative profles, for a variety of architectural features ranging from window hoods to columns, piers, balustrades, and even whole façades. Cast iron offered its own set of effciencies including cost, fabrication time, and weight, but required a painted fnish.

While cast stone, terra cotta, and cast iron offered effciencies over quarried and, particularly, carved stone, they were not cheap or impermanent materials. Less costly, but also less durable, stamped or brake-formed sheet metal, typically galvanized, could also be used instead of masonry for cornices, window hoods, roofng tiles, and even entire building façades.

Substitute Materials and Applying the Standards for Rehabilitation

The *Standards for Rehabilitation* are focused on preserving the important and distinctive character-defning features of a historic property (Standards 2 and 6), and they are to be applied in a reasonable manner, taking into account economic and technical feasibility (36 CFR 67.7 and 36 CFR 68). The Standards have an inherent fexibility that facilitates their application to diverse projects, historic properties, and conditions. They are to be applied on a "cumulative-effect" basis, when the overall effect of all work in the context of the specifc conditions of the property and the project is consistent with the property's historic character.

The *Standards for Rehabilitation* require that the replacement of a distinctive feature match the old in physical and visual properties. While the use of matching materials is always preferred, the Standards purposely allow for the use of substitute materials when the use of original materials is not reasonably possible, such as in consideration of economic and technical feasibility or in new construction. They also provide additional fexibility in the treatment of secondary, less distinctive features that are less important in defning the historic character of the property. The *Standards for Rehabilitation* recognize that fexibility is appropriate to facilitate "a compatible use for a property … while preserving those portions or features which convey its historical, cultural, or architectural values" (defnition of "Rehabilitation," 36 CFR 67.2(b)).

Examples of Historical Use of Substitute Materials



Figure 2a. Casting concrete blocks to mimic quarried stone was a popular late 19th- to mid 20th-century technique. Concrete masonry units could be completed by local craftsman, saving time and shipping costs. Photo: John Sandor, NPS.



Figure 2b: The 19th century also produced a variety of metal products used to imitate other materials. Across the country, cast iron was used in storefronts to imitate stone. Photo: John Sandor, NPS.

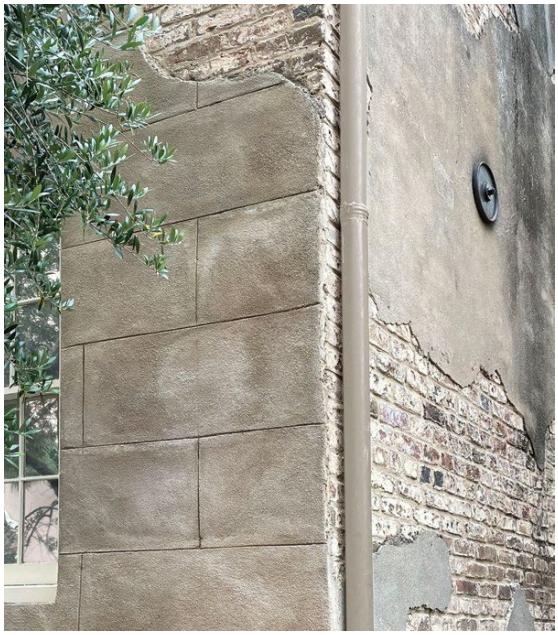


Figure 2c: Stucco has been used to imitate a number of building materials for many centuries. Seen here, stucco was applied to a brick structure and scored to represent a stone façade. Photo: John Sandor, NPS.

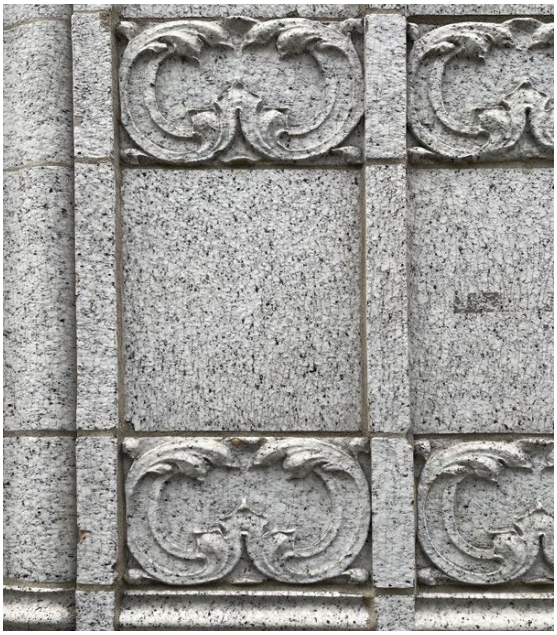


Figure 2d: Terra cotta gained popularity in the late 19th century as a cheap and lightweight alternative to stone. Glazing techniques allowed the blocks to imitate a variety of natural stone materials. Photo: John Sandor, NPS.

These examples of one material used to imitate another, more often in initial construction than for later repair and replacement purposes, are referred to as *imitative materials* in the *Guidelines for Preserving, Rehabilitating, Restoring & Reconstructing Historic Buildings*, updated in 2017, that accompany the *Secretary of the Interior's Standards for the Treatment of Historic Properties*. These imitative materials, while evoking other materials, usually had distinctive qualities of their own and were not always a very close match in appearance to the historic material they were meant to imitate.

Many of the traditional materials discussed above are still available and used to replace damaged or missing original features, both to replace matching historic materials and sometimes as substitute materials. Because of their extensive use over time and their known physical and chemical properties, cast stone, cast iron, and terra cotta are well understood substitute materials. This continued usage and familiarity means their installation requirements and service life are well established, which in turn makes it easier to determine when and how to use these traditional materials as substitutes for a deteriorated material. However, innovation in replacement materials continues, and new products (many of them consisting of synthetic materials) are continually introduced. These non-traditional products are an increasing part of both the new construction and rehabilitation industries. Some materials, like glass fber reinforced polymers, glass fber reinforced concrete, or fber cement, have been in use long enough for an accurate prediction of their service life and performance. Other newer, non-traditional materials may be too new to have established performance records, thus, understanding their material properties is critical, and their use should be approached with more caution.

When to Consider Using Substitute Materials in Preservation Projects

According to the *Standards for Rehabilitation*, deterioration should generally be addressed through repair if in repairable condition. Repair can entail a variety of treatments that retain the unit of building material and remove and patch or replace only the damaged portion. This approach can be done with traditional methods and materials such as a dutchman, where like-kind material is precisely inserted into wood or stone, or it may employ other materials such as epoxies for wood repair or cementitious compounds for masonry. As long as the repair methods are sound and do not damage or accelerate the deterioration of the historic material, repairs are generally preferable to replacement of an entire element. More complex manufactured products, typical of more recent historic materials (as well as a lot of modern building materials generally), may be more diffcult to repair, if they can be repaired at all.

There are situations, however, when the level of deterioration makes localized repairs infeasible and entire features or units of historic material must be replaced. While achieving an effective match of all of the visual qualities of a material can be challenging, even when replacement is in kind, it can be even more challenging when the replacement is a substitute material. A good visual match is not the only consideration when a substitute material is to be used for incremental replacement within a larger assembly of historic material. When an individual siding board or a single block of ashlar is being replaced, it is usually best achieved with the original material. Introduction of a different material into an intact assembly requires that its inherent properties, such as expansion and contraction, moisture resistance, or permeability, be thoroughly considered relative to those of the surrounding historic materials to avoid causing damage.



Figure 3: Incremental repair is best done using in-kind material to minimize diferences in the performance characteristics that could negatively afect the overall assembly. Photo: NPS.



Figure 4. While occasionally used to imitate other materials such as wood or slate shingle, many asbestos shingles and siding materials had their own distinct shape and profle. No longer manufactured today, alternative materials must be found to replace these materials when they are distinctive features on a historic structure. Drawing: Association for Preservation Technology, Building Technology Heritage Library.



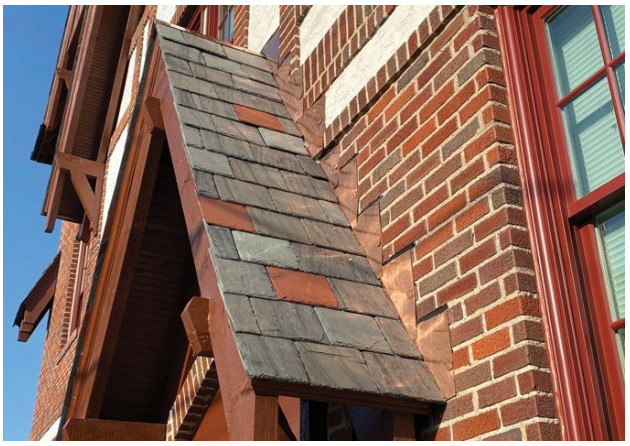


Figure 5. (Left) Asbestos shingles were often used as a substitute for traditional slate roof shingles. The historic asbestos roof on this rehabilitation project had reached the end of its lifespan and required complete replacement. (Right) Given the limited replacement materials available to match the historic asbestos shingles, utilizing natural slate was determined to be the best visual match for the original shingles and design intent in this instance. Photos: Crosskey Architects.

Circumstances in which the use of substitute materials may generally be considered appropriate, taking into consideration technical and economic feasibility reasons, include: the unavailability of historic materials; the unavailability of skilled artisans or historic craft techniques; inadequate durability of the original materials; the replacement of a secondary feature; construction of a new addition; the reconstruction of a missing feature; code-required performance; and for enhanced resilience and sustainability:

- **Unavailability of historic material.** A common reason for using substitute materials is the diffculty in fnding a good match using the historic material (particularly a problem for masonry materials where the color and texture are derived from the material itself). This may be due to the actual unavailability of the material or to protracted delivery dates, particularly if the material cannot be sourced domestically. It is not uncommon for a local quarry that is no longer in operation to have been the source of an original stone. If another quarry cannot supply a satisfactory match, a substitute material such as dry-tamp cast stone or textured precast concrete may be an appropriate alternative, if care is taken to ensure that the detail, color, and texture of the original stone are matched. Even when the color is successfully matched, the appearance of a cementitious product may diverge from that of the historic stone as the substitute material ages.

  Many manufactured materials that were used historically on buildings are no longer made. Terne-plated steel, which was the material most typically used for painted standing-seam or fat-seam roofng, is no longer made. However, because it was always painted, other metals including galvanized steel or copper can generally be substituted if painted. When the historic material needing to be replaced is a manufactured product developed as an imitation of a natural material, which was the case with asbestos shingles meant to imitate slate, the natural material may now be an appropriate substitute material to consider for the manufactured one that is no longer produced.

- **Unavailability of skilled artisans or historic craft techniques**. These two issues can complicate any preservation or rehabilitation project. This is particularly true for intricate ornamental work, such as carved wood, carved stone, wrought iron, or cast iron. While skilled craftsmen may not be as diffcult to fnd as they once were, there can still be limitations geographically, even in fnding less specialized skills, and particularly if a project is small. Technical advances have allowed some stone or wood carvers to take advantage of computerized equipment, but complex designs will likely still require hand work. It may also be possible to mimic a carved element using a material that can be cast in a mold, adding signifcant effciency where an historic element survives from which a mold can be made. Options for casting include aluminum, cast stone, fberglass, glass fber reinforced concretes, and terra cotta, but not all carved elements can be duplicated by a casting, and mold-making and casting still require skilled craftsmen.

- **Inadequate durability of the original material.** Some historic building materials were of inherently poor quality or were not durable. In other cases, one material was naturally incompatible with other materials on the building, causing staining or galvanic corrosion. Examples of poor-quality materials are very soft sandstones, which eroded quickly, and brownstone, which is vulnerable to delamination. In some cases, more durable natural stones may be visually similar enough to stand in for these soft stones but cast stone or another material may be needed to achieve an appropriate match.

The ready availability of manufactured ornamental wood features fed a nineteenth-century taste for decorative architectural details that were often used on the exterior of buildings with little concern for how they would be affected by moisture or maintained. Even old-growth wood from decay-resistant species often could not prevent features with severe exposure from eventually needing to be replaced. Today's available commercial supplies of lumber no longer provide the denser, more decay-resistant wood of old-growth forests, so even careful matching to species, which is not always possible, will not yield a replacement equal in performance to the historic material. Old-growth wood is likely to be very expensive, if it can be found, and may not be available from a sustainable, environmentally responsible source. When features with severe exposure need to be replaced or reproduced, substitute materials that are less susceptible to decay can have a longer life, and when the feature is painted, as exterior wood features generally are, the visual effect of a substitute material can be minimal.

- **Replacement of a secondary feature.** When it is necessary to replace a less distinctive, secondary feature that is less important in defning the historic character of the property, there is more fexibility in how it can be replaced. While it may be less important to fnd an exact match in materials when replacing such a feature, the retention of the overall historic character should still guide selection of an appropriate replacement material. For example, replacing secondary features such as those with limited visibility (e.g., siding materials on a rear elevation) may permit replacement materials that are similar in appearance or character without having to be a perfect match.



Figure 6. The dramatic diference in the number of growth rings between old-growth wood and wood that was recently harvested from second- or third-growth forests is indicative of the diminished dimensional stability and durability of most lumber currently available. Photo: Zachary Dettmore.

- **Construction of a new addition.** The *Standards* require that new additions to historic buildings and related new construction be differentiated from the old as well as be compatible with the historic character of the property and its site and environment. Using materials that evoke, without matching, the historic material can be an effective means of achieving the needed balance between compatibility and



Figure 7. A new addition replaced non-historic construction on the rear elevation of this building. Fiber cement gives the addition a compatible appearance without replicating the exposure for thickness of the historic siding. Photo: Ward Architecture + Preservation.

differentiation for new additions and new construction. Even if differentiation is achieved through design rather than materials, there generally is no basis for requiring the use of matching historic materials for new additions and new construction as part of a rehabilitation project.

- **Reconstruction of a missing feature.** Many buildings lose signifcant features over the course of their lives for reasons such as those previously discussed. When a missing feature is to be reconstructed, the importance of matching the original material may be less important to the effect replacing the missing feature may have on the overall historic character and appearance of the building. Though replacement of missing features must be substantiated by documentary, physical, or pictorial evidence, in many cases the authenticity of the material may be secondary to the overall visual qualities. The use of a more cost-effective substitute material for the construction of a missing feature can often be an important factor in the feasibility of undertaking such work.

- **Code-required performance.** Modern building codes are regularly amended to require higher performance levels for new and existing buildings in such areas as life safety, seismic retrofts, and accessibility. Rehabilitation projects often trigger compliance with code requirements that were not in place when a building was constructed. Although building codes may often allow for the retention of historic materials and assemblies, substitute materials can offer an alternative in situations when the historic materials are non-compliant and cannot otherwise be reasonably retained. In these instances, a change in material may be appropriate to meet code requirements, while in other instances selecting the optimal code compliance method for the project may achieve code-compliant solutions that also allow for the preservation of a building's historic materials and fnishes.

  For example, fre codes may require increased resistance to fame spread for buildings within dense urban environments where building proximity and separation between buildings is a concern. Some substitute materials are non-combustible, have good ratings for fame spread, and can provide an alternative to help meet

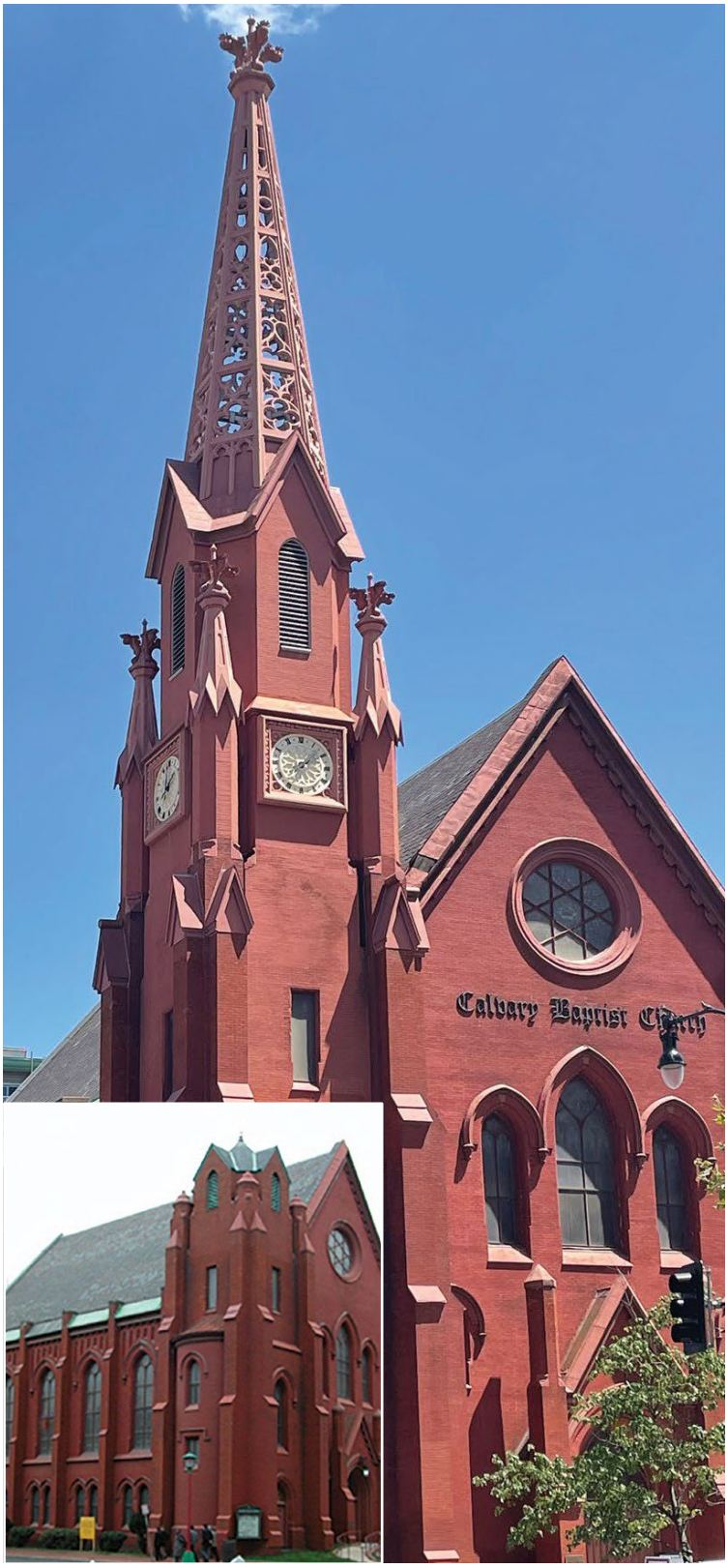


Figure 8. A long-missing cast-iron steeple was reconstructed in aluminum and fber-reinforced polymer (FRP). Photo: John Sandor, NPS, Inset: Quinn Evans.

fre code requirements. Depending on the building component and the material, however, a substitute material may not resist fre any better than the historic material. In addressing code issues, all feasible alternatives should be considered to minimize the impact on the historic character of the building while still meeting code requirements.

With specifc provisions in building code related to issues such as seismic hazards, the choice of materials for features inherently unstable in a seismic event can be a key part of a code-compliant retroft solution. Elements at risk of falling such as parapets, fnials, and overhanging cornices may be made safe by anchoring them to new structural frames. However, for some heavy masonry features, especially where there is deterioration or the feature is diffcult to effectively brace, adequately anchoring the existing feature may not prove feasible. In such cases removing and replacing these features with lighter-weight replicas that incorporate a resilient structural framework can help preserve the historic character of the building while improving life safety performance.

- **Enhanced resilience and sustainability.** Wildfres, earthquakes, foods, hurricanes, and other extreme weather events put historic buildings and their occupants at risk and may require adaptive treatments that are more invasive than might be accepted in other circumstances, including related to the use of substitute materials. In these contexts, it is still necessary to try to minimize impacts on a building's historic character as much as possible while still adapting it to be more resilient. Widespread wildfres, for example, have increased demand for fre resistant materials for the exterior building envelope. Flood events may necessitate the replacement of historic materials that have been damaged or inundated with hazardous substances in contaminated foodwaters. When undertaking repairs in such circumstances, substitute materials may offer greater resilience to anticipated future exposure to natural hazard risks.

  Similarly, efforts to improve energy effciency and performance may include the use of substitute materials as replacement components when modifcations to building assemblies are required and the historic materials cannot be preserved. When evaluating substitute materials in the context of sustainability objectives, factors such as the environmental impact of production, the full life cycle of products, and the embodied carbon of the materials already in place should be carefully analyzed. There may be more sustainable choices for a replacement material, including the use of more traditional materials in place of manufactured products that may consist of non-renewable resources or hazardous materials. While some synthetic substitute materials are made from recycled materials or are otherwise sustainably produced, many are not repairable, salvageable, or recyclable themselves, and they may have shorter lifespans to their historic material counterparts. When either greater resilience or sustainability is a factor, all feasible alternatives should be considered in fnding a balanced approach that maintains historic character while meeting resilience and sustainability goals.

Substitute Materials and Economic Feasibility

Economic feasibility is inevitably a concern when choosing a material for any part of a project, whether a historic or substitute material, but it should not be the sole determinant factor at the expense of maintaining the historic character and historic integrity of a building. Other factors may prompt the consideration of a substitute material, such as the cost of maintaining the historic material, because it is comparatively diffcult or costly to reach or access, or the frequency of required maintenance the historic material needs. Additionally, where in-kind replacement material is found to be prohibitively expensive, it may be reasonable to consider a substitute that offers an alternative and is a good physical and visual match. Not all substitute materials are, however, cost-effective replacements. Long-term durability and maintainability are other factors that should be considered in conjunction with initial cost.



Figure 9. Previously bricked-in openings below the food line were reopened and new aluminum windows installed with cellular PVC trim detailed to hold back moderate food waters and survive exposure to water. Photo: John Sandor, NPS.

Maintenance of a material, particularly where accessibility is diffcult or expensive, can be an important part of a

cost evaluation. Maintenance costs should not be considered without also considering life-cycle expenses. While some substitute materials may offer reduced initial costs, they may be as or more costly than traditional materials to maintain over time. For example, many substitute materials are not readily repairable, necessitating full replacement when damaged. The cost to replace a material or assembly at the end of its lifespan may also be greater than the accumulated incremental expense to maintain the historic material, particularly if it is a more traditional, repairable material. Maintenance cost should never be the sole reason for replacing a historic material that is not deteriorated.

Criteria for the Appropriate Use of Substitute Materials

Substitute materials must meet three basic criteria to be considered: they must be compatible with the historic materials in appearance; their physical properties must be similar to those of the historic materials, or the materials must be installed in a manner that tolerates differences; and they must meet certain basic performance expectations over an extended period of time.

- **Matching the Appearance of the Historic Material**
  Any material's appearance varies depending on the nature of the material and how it is used. Some historic materials, such as wood and ferrous metals, were typically painted, making the color of the substitute unimportant, though the texture of the surface, which telegraphs through a paint layer, is still an important consideration. Texture can be a large part of distinguishing a material formed by hand from one that is machine-made. Many historic materials, such as most building stones, are used without any coating, making the color, pattern, and refectivity, as well as surface texture, dependent on the material itself. Matching the color and surface characteristics of a historic natural material with a man-made substitute can often be quite diffcult.

  When the color and surface characteristics of an existing material are important, cleaning the material should be the starting point for evaluating a potential matching material. In situations where there are subtle variations in color and texture within the original material, the substitute material should be similarly varied so that it is not conspicuous by its uniformity. If a material is custom fabricated, a suffcient number of samples should be supplied to permit on-site comparison of color, texture, detailing, and other critical visual qualities. For a manufactured product with preset choices of color or texture, it may be necessary to look at samples from more than one manufacturer to fnd the best match. Similarly, prefabricated products, such as roofng slate, may offer limited, if any, choice of unit size, which can be a critical factor for achieving a good match. A substitute material should not be used to replace distinctive, character-defning materials and features if an adequate match in design and appearance is not possible.

  As all exposed materials are subject to ultraviolet degradation, samples of a new material, particularly when custom formulated, should be prepared during the early planning phases to allow for evaluation of the effects of weathering on color stability. When that is not possible, or if a prefabricated product is used, the fabricator or manufacturer may be able to identify regional locations where equivalent products have been installed long enough ago to get a better sense of how the material weathers and performs.

  While a perfect match is the desired goal for replacing distinctive features, it is not always possible, even when the same matching material is chosen for the replacement. When any compromise





Figure 10. Polymer slates offer a choice of shapes but not sizes, limiting their ability to achieve a good visual match for some historic slate. With the size of the polymer slates (right) being nearly twice that of the historic slates (left), the scale of the entire feature is incompatibly altered. The molded edges of this material, which contribute to its ability to replicate slate, would be lost if each shingle was resized by cutting. Photo: John Sandor, NPS.

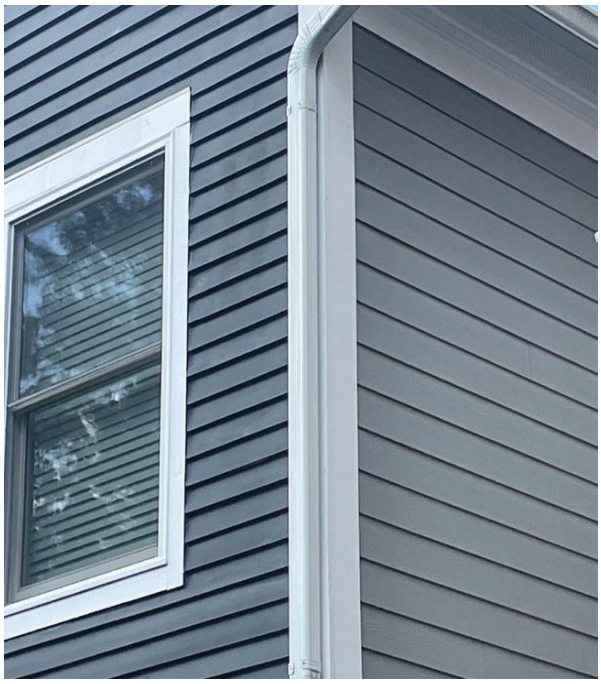


Figure 11. The thickness of the wood siding on the front (left) creates a deeper shadow line than is achieved with the fber cement siding used on the side (right) elevation. While the exposure can be adjusted, fber cement siding is not available in a matching thickness. Photo: John Sandor, NPS.

must be made in the precision of the match, it is wise to consider the vantage point from which the material will be seen. Sometimes what seems important at close range, such as variations in the texture of a surface, may be secondary to other aspects of the material when viewed from some distance. The closer a feature is to the viewer, the more closely the material and craftsmanship should match the original. An on-site mock-up using a sample of the proposed material can help evaluate whether it is an adequate visual match.

- **Matching the Physical Properties of the Historic Material**
  Carefully chosen substitute materials can often closely match the appearance of historic materials, but their physical properties may differ greatly. These differences are most critical when incrementally replacing components of a larger assembly that retains signifcant historic material. The chemical composition of the material (e.g., the presence of acids, alkalis, salts, or metals) should be evaluated to ensure that the replacement materials will be compatible with the adjacent historic materials. Materials that will cause galvanic corrosion or other chemical reactions must be isolated from one another.

  The thermal- and moisture-driven expansion and contraction coeffcients of each adjacent material must be within narrow limits or be accommodated by carefully designed joints and fasteners. Joints can play a role both in accommodating movement of materials as well as in managing moisture, either to keep it from entering the enclosure assembly or to let it escape from the building envelope, or both. Because some synthetic materials are less permeable to moisture than more traditional materials, installations must take into account the potential to trap moisture and cause deterioration of historic and new materials. An assembly incorporating new and historic materials should be designed so that if material failures occur, the failures occur within the new material rather than the historic one.



Figure 12. Cellulose composite materials, like wood, expand and contract with moisture. Here it was used to reconstruct a missing storefront. Unlike solid wood that is dimensionally stable parallel to the grain, this composite moves equally in all dimensions, resulting in gaps that were not adequately anticipated in the design. Photo: John Sandor, NPS.

  During installation, surface preparation is critical to ensure proper attachment. Deteriorated underlying material must be removed or stabilized. Non-corrosive anchoring devices or fasteners that are designed to carry the new material and to withstand wind, rain, snow, and other destructive elements should be used. Since physical failures often result from poor anchorage or improper installation techniques, a structural engineer should be included in planning any major project. For readily available, off-the-shelf materials, manufacturers' recommendations for attachment and spacing should be followed.

  Nearly all substitute materials have some properties that are different from the historic materials they may replace. Even when substitute materials are isolated from historic materials and features, it is important to understand the substitute materials' properties in order to use them successfully.

- **Performance of the Material Over Time**
  When more traditional materials are used to replace damaged historic materials and features, their performance is predictable in most cases. An exception may be modern wood that has durability and other prop-

erties different than those of historic wood from old-growth forests. Many of the materials used as substitutes have been in use long enough to provide some idea of how they perform over time. Other material may only have test results from accelerated weathering. The length of manufacturer warranties may be an indicator of expected durability and lifespan. Warranties only predict a manufacturer's expectation of a product's performance and are no guarantee that the manufacturers will still be in business at the time needed to stand behind them. Just as new manufacturers emerge with new materials, others disappear. Where possible, projects involving substitute materials in similar installations and exposures should be examined before selecting a new, less-tested material. It is unrealistic to expect a substitute material, which can be quite different in composition than the historic material, not to age differently.

Even traditional materials will not perform well if not used or detailed appropriately, and experienced architects, engineers, fabricators, and installers rely on their professional knowledge and experience to ensure proper installation and techniques when working with familiar materials. This is just one of many reasons that using the original materials for needed replacement is usually the best choice. Some of the materials now available as substitutes have properties that differ greatly from the traditional materials they may be used to replace. It is critical to the successful performance of substitute materials that everyone involved in the selection, design, and installation fully understands the material's properties, especially how it is different than the material it is replacing, and how that will affect the surrounding materials and building systems.

Many traditional building materials can be repaired either with traditional methods and materials or with more modern conservation techniques using substances like epoxies. However, many modern substitute materials (particularly synthetic ones) are not as easily repaired, if repairable at all, as their more traditional counterparts. Confrming that a material is repairable may be important for those used, e.g., where impact or signifcant wear or abrasion is likely.

Finally, it is critical that the substitute materials be documented as part of the historical record of the building so that proper care and maintenance of all of the building materials continue, ensuring the continued life of the historic building.

Choosing an Appropriate Substitute Material

Once all reasonable options for repair and replacement in kind have been considered and suffcient justifcation for substitute materials has been established, the choice among the variety of substitute materials currently available must be made. Rapidly developing technologies allow a wide variety of materials to choose from that are intended to mimic historic materials. Many of the materials that were historically used as substitutes for more traditional historic materials have themselves become historic, and some of these early substitutes continue to be reasonable options as substitute materials today. No substitute material will exactly match the historic material in all aspects, but many are able to adequately match the appearance and relevant physical attributes to make for a potential substitute. If a substitute material is not

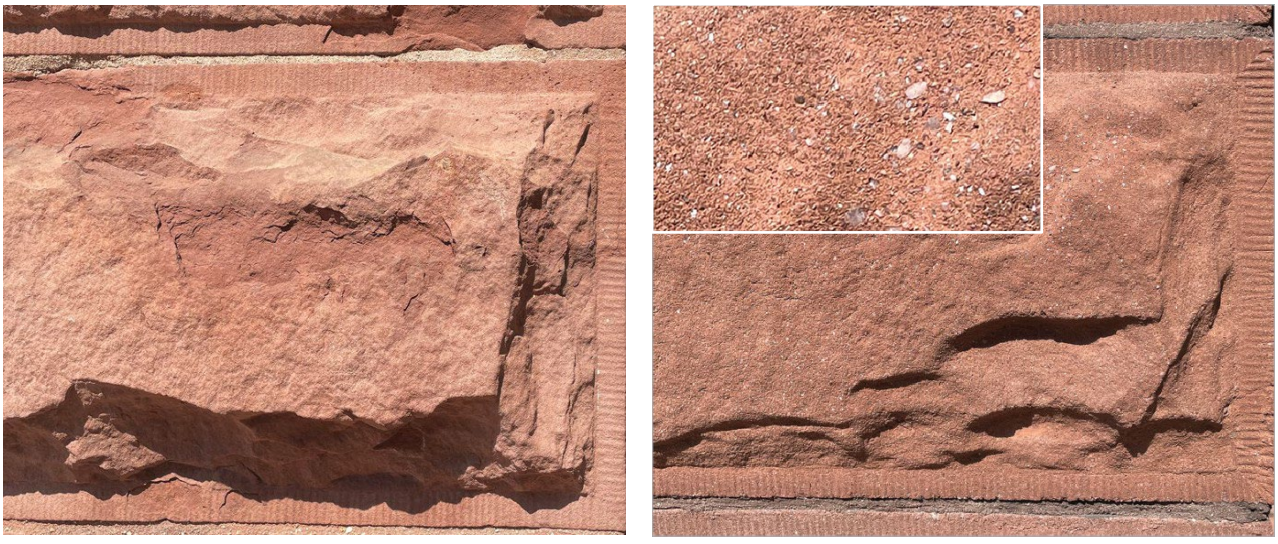


Figure 13. Cast stone was used to efectively replace individual blocks of sandstone. Both the original (left) and the substitute material (right) retain similar physical and visible properties. Having weathered for over 30 years, some erosion of the binder has revealed quartz grains of the aggregate (inset), but it is only noticeable upon close inspection. Photo: John Sandor, NPS.

an adequate physical and visual match given the specifc conditions of the building and the project, then it should not be used to replace distinctive, character-defning materials and features.

Listed below are various building components or features and the substitute materials which may, in some circumstances, be considered for use as possible replacement materials in a historic rehabilitation project consistent with the *Standards for Rehabilitation*. This list includes different substitute material options available today for these building features and poses questions that should be asked and considered when choosing between the original material and various types of substitute materials. This is followed by a list of some of the more commonly used, currently available materials that may have some applications as substitute materials and the properties of each that affect their suitability for use as substitutes. This list should not be read as an endorsement of any of these materials, generally, or their appropriateness for use as a substitute material, but it serves as a reminder that the successful use of any building material requires a careful consideration of its properties relative to where and how it will be used.

Considering Substitute Materials

Considering the use of a substitute material should begin with the following questions about the conditions and location where it will be used:

- Will the signifcance or visibility of the historic feature require a very precise match?
- Is the entire feature being replaced or just a component of it?
- Are pre-existing conditions contributing to the failure of the existing material, and, if so, how will they be addressed/corrected?
- Is the need for replacement due to inherent defciencies of the original material?
- Will the material need to resist any environmental hazards such as fooding or fre?

Historic Features and Substitute Materials

Historic Building Features

Potential Substitute Materials	**Masonry** Stone, terra cotta	**Architectural Metals** Cast & wrought iron, steel, pressed metal	**Siding** Wood, asbestos	**Roofng** Wood shingle, slate, tile	**Decking** Tongue and groove & square edge wood	**Molding / Trim** Wood
Aluminum	●	●	●			●
Cast Stone & Precast Concrete	●			●		
Fiber Reinforced Concretes	●					
Glass Fiber Reinforced Polymers	●	●				
Fiber Cement			●	●		●
Mineral / Polymer Composite			●	●	●	●
Cellulose Fiber / Polymer Composite			●	●	●	●
Non-composite Polymers		●			●	●
Cellular PVC			●		●	●

The above chart lists materials that are sometimes used as substitutes for replacement of historic building features. Even within a given category, all materials may not be equally suitable as a substitute replacement material for the actual historic material or feature. Any substitute material should be selected based on its specifc physical and visual characteristics, conditions, and intended application consistent with the Secretary of the Interior's Standards for Rehabilitation.

Historic Building Features: Criteria for selecting an appropriate replacement material

Masonry

FEATURES: corbels, brackets, balusters, cornices, window and door surrounds, friezes, wall surfaces, horizontal surfaces, incidental ornament, columns

HISTORIC MATERIALS: terra cotta, cast stone, stone, concrete

POTENTIAL SUBSTITUTES: cast stone, pre-cast concrete, GFRC, GFRP, non-composite polymers (polyurethane), cast or stamped metal

Questions to ask about the replacement material:

- Can it serve a structural function?
- How is the material affected by moisture?
- Can the material survive fooding and be reused?
- Can it reproduce the surface texture of the original?
- Is its shrinkage in curing low enough to allow it to be molded from existing stones?
- Can matching color be achieved without a coating and with UV stability?
- Can an adequate match of the surface (color and texture) be achieved with a coating?
- Is a coating required?
- If it is not self-supporting, is it lightweight enough to be supported by an underlying framework?
- Can multiple original units be replicated with a single replacement piece?
- Where thermal movement is different from the original material, how will joints accommodate?
- Is the material combustible?

Architectural Metals

FEATURES: pilasters, door and window surrounds, cornices, incidental ornament, columns, spandrels, ceilings, sheathing, roofng

HISTORIC MATERIALS: cast and wrought iron, steel, bronze, lead, aluminum, and stamped steel (usually galvanized or terne-coated)

POTENTIAL SUBSTITUTES: GFRP, aluminum, non-composite polymer (polyurethane), GFRC, metallic/polymer composite

Questions to ask about the replacement material:

- Will the replacement material serve a structural or cosmetic role?
- Will it expand and contract with temperature change enough to require special accommodation in its installation?
- If part of an assembly of mixed materials, how will any expansion and contraction of the dissimilar materials be accommodated?
- Will the replacement material increase deterioration of the historic or surrounding elements, for instance due to galvanic corrosion, moisture entrapment, jacking of original material, off-gassing creating a corrosive environment, or poor original design of the historic material?
- How will the replacement material mimic the surface color/patination of the original material?
- If a coating is needed, what preparation is needed, and what is its durability or service life of the fnish?
- What attachment and support systems are necessary?
- If the original element is structural, but the new material is not, how can supplemental structure be introduced to support the new?





Figure 14. Surface texture is an important aspect in matching the appearance of a historic material, especially when a material is viewed at close range. As seen in these two images, many of the substitute materials produced for siding and trim have an embossed wood grain, making them incompatible for replacing historic wood that was typically planed to a smooth surface. Some substitute products are available with a smooth surface as well. Photos: John Sandor, NPS.

Siding

FEATURES: clapboard, tongue-and-groove or shiplap siding, board and batten, shingles

HISTORIC MATERIALS: wood and asbestos

POTENTIAL SUBSTITUTES: cellular PVC, wood fber/polymer composite, fber cement, mineral/polymer composite

Questions to ask about the replacement material:

- What are the widths, lengths, profles, thicknesses, and textures available?
- What, if any, are the fnishing requirements, and/or is it available factory-fnished?
- How well does it hold paint, and can prefnished surfaces be renewed?
- What tools are needed to cut it, and can it be machined?
- Does it absorb moisture and, if so, to what effect?
- Can the material survive fooding and be reused?
- Will it expand and contract with temperature change enough to require special accommodation in its installation?
- What characteristics can affect its handling (e.g., weight, fexibility, brittleness)?
- Does it have specifc fastening requirements?
- Is it susceptible to insect damage?
- What is its impact resistance?
- Does it have a fame spread rating?
- What is the expected lifespan and/or warranty?

Roofng

HISTORIC MATERIALS: wood shingle, slate shingle, asbestos shingle, clay tile, concrete tile, metal

POTENTIAL SUBSTITUTES: fber cement, mineral/polymer composite, wood fber/polymer composite, pre-cast concrete, metal

Questions to ask about the replacement material:

- What sizes and shapes are available?
- What are color choices?
- What is the color stability of the new material, and how will it age/weather?
- What is the impact resistance?
- What is its fame spread rating?
- What are the installation requirements of the new material?
- Can the feature being replaced be custom-produced if ready-made ones of the new material are not an accurate match?
- What is the expected lifespan and/or warranty?

Decking

FEATURES: tongue-and-groove, square-edge fooring

HISTORIC MATERIALS: wood

POTENTIAL SUBSTITUTES: cellular PVC, wood fber/ polymer composite, mineral/polymer composite, non-composite polymers (solid PVC)

Questions to ask about the replacement material:

- What are the widths, lengths, and textures available?
- Is it site painted or prefnished?
- How well does it hold paint, and can prefnished surfaces we renewed?
- What tools are needed to cut it, and can it be machined?
- What dimensional span does its strength allow?
- Does it absorb water, and if so, to what effect?
- Can the material survive fooding and be reused?
- Does it require a drainage plane, or can it be installed atop a membrane?
- Will it expand and contract with temperature change enough to require special accommodation in its installation?
- Is it susceptible to insect damage?
- Is it impact resistant?
- Does it have a fame spread rating?
- What is the expected lifespan and/or warranty?

Molding / Trim

FEATURES: run moldings, fat boards, casings, cornice, frieze, railings, balustrade, columns

HISTORIC MATERIALS: wood, metal

POTENTIAL SUBSTITUTES: cellular PVC, wood fber/ polymer composite, mineral/polymer composite, non-composite polymer (polyurethane), GFRP, sheet metal

Questions to ask about the replacement material:

- What are the widths, lengths, and textures available?
- What, if any, are the fnishing requirements and/or is it available factory-fnished?
- How well does it hold paint, and can prefnished surfaces be renewed?
- What tools are needed to cut it, and can it be machined?
- Does it absorb moisture, and if so, to what effect?
- Can the material survive fooding and be reused?
- Will it expand and contract with temperature change enough to require special accommodation in its installation?
- What characteristics can affect its handling (e.g., weight, fexibility, brittleness)?
- Does it have specifc fastening requirements?
- Is it susceptible to insect damage?
- What is its impact resistance?
- Does it have a fame spread rating?
- What is the expected lifespan and/or warranty?



Figure 15. Tongue-and-groove porch fooring is manufactured in several diferent substitute materials. Each type has diferent properties, though most are more moisture-resistant than wood. The prefnished product shown can be painted when worn, but repainting is not recommended for some product choices. Photo: Oak Alley Foundation.

Potential Substitute Materials: Matching properties and performance needs

Physical Composition and Properties

After assessing different material options based on the intended application, the appropriateness of a substitute material should also be considered in context of the material's physical composition, associated properties, and necessary visual match.

Aluminum

MATERIAL: Aluminum is a highly corrosion-resistant alloy that can be cast, wrought, or extruded. Molten aluminum is cast into permanent (metal) molds or one-time sand molds forming cast aluminum. Extruded aluminum is formed by passing heated aluminum through a die which produces the desired form. Wrought aluminum is worked using the heated metal and then bending, stamping, and otherwise shaping the metal. If not self-supporting, aluminum elements are generally screwed or bolted to a structural frame. Aluminum can be welded, but more often sections, particularly extruded ones, are mechanically connected.

PROPERTIES:

- Isotropic
- Lightweight
- Thermal movement greater than cast iron or wood
- Corrosion-resistant, but direct contact with other metals may trigger galvanic corrosion
- Lower structural strength that iron or steel
- Ductile - less brittle than cast iron
- Non-combustible
- Retains high defnition through molding process and produces crisp profles through extrusion
- Can be given a durable metallic fnish through anodization. Surface etching required for paint adhesion
- Can be machined into a large variety of shapes/ dimensions



Figure 16. Aluminum is a highly corrosion-resistant metal that is commonly used as a substitute material for cast iron. Aluminum can be a more afordable and lightweight alternative to cast iron that retains a similar texture, shape, and maintenance cycle. Photo: NPS.



Figure 17. The balustrade consists of multiple prior campaigns of using cast stone to replace the natural stone. The efective match for the surface texture and color of the original stone allowed individual elements to be incrementally replaced only when they had failed, thus retaining the maximum amount of original material as long as possible. Photo: EverGreene Architectural Arts.

Cast Stone & Precast Concrete

MATERIAL: A cement lime and aggregate mixture that is dry-tamped into a mold is generally referred to as cast stone. Cast stone is one of the original substitute materials. Its longevity has proved that the material ages compatibly with stone. A wet mix of cement and aggregate poured into molds also has a long history of being used to produce concrete masonry units mimicking stone and roofng tiles mimicking clay tile. Both methods have minimal shrinkage during curing, though they employ different curing and fnishing techniques. Both can include reinforcing bars and anchorage devices installed during fabrication. The dry-tamp fabrication method is especially effective at producing an outer surface with the appearance of stone.

PROPERTIES:

- Isotropic
- Weight equivalent to stone
- Expansion/contraction similar to stone
- Water absorption may differ from that of any particular stone
- Can be structural
- Non-combustible
- Vapor-permeable
- May achieve a wide range of color and surface textures by varying mix, but use of pigments may reduce UV stability
- Can be coated
- May be tooled to match the appearance of tooled stone
- Repairs similarly to stone



Figure 18. Missing historic terra cotta spandrel panels on all four levels were recreated utilizing glass fiber reinforced concrete (GFRC) replacements. New spandrels were fabricated as individual components and attached with metal clips between historic terra cotta piers. Photo: Kris Frail, Dewberry.

Fiber Reinforced Concretes (GFRC, CFRC)

MATERIAL: Fiber reinforced concretes are lightweight concrete compounds modifed with additives and reinforced with alkaline resistant glass fibers (GFRC), or less frequently carbon fibers (CFRC). They are generally fabricated as thin-shelled panels and applied to a separate structural frame or anchorage system. GFRC is typically sprayed into forms, although it can be poured, and anchoring devices are included in the fabrication. The color is derived from the natural aggregates and, if necessary, a small percentage of added pigments. Because of its low shrinkage in curing, it can be produced using molds taken directly from the building.

PROPERTIES:

- Isotropic
- Lighter weight than solid masonry
- Expansion/contraction similar to stone
- No load bearing capacity, so underlying framework must be used to accommodate any loads
- Material can be fre-rated
- Vapor-permeable
- Can be produced in larger sections effciently reproducing repetitive elements or features that were originally made up of small individual units
- Large range of colors achievable by varying aggregates, but when pigments are needed UV stability may be reduced
- May be left uncoated or may be painted



Figure 19. A new, lightweight fber reinforced polymer is attached to a new metal armature to replicate damaged and missing elements of a terra cotta cornice. Photo: Quinn Evans.

Glass Fiber Reinforced Polymers (FRP, Fiberglass)

MATERIAL: Fiberglass is the most well-known of the FRP products generally produced as a thin, rigid, laminate shell formed by pouring a polyester or epoxy resin gelcoat into a mold. When tack-free, layers of chopped glass or glass fabric are added along with additional resins. The surface gel coat can be pigmented or painted. Reinforcing rods and attachment devices can be added when necessary. Because of is low shrinkage in curing, it can be produced using molds taken directly from the building. Rather than being produced as standard components, FRP is custom fabricated for individual applications.

PROPERTIES

- Isotropic
- Lighter weight than masonry, similar to sheet metal
- More thermally driven expansion than masonry or metals
- No load bearing capacity, so underlying framework must be used to accommodate any loads
- High strength to weight ratio
- Flammable
- Not vapor-permeable
- Can be produced in larger sections effciently reproducing repetitive elements or features that were originally made up of small individual units
- May be diffcult to match false joints in multi-unit assemblies to actual joints that need to accommodate movement
- Color can be incorporated into the surface gel-coat, or the surface may be coated



Figure 20. Cement board was used to replace a non-historic infll and mimics the confguration of a typical vehicular door of the period. Photos: Historic Augusta.

Fiber Cement

MATERIAL: Fiber cement products are made from fber, sand that is ground to a powder, cement, and proprietary additives to reduce moisture absorption. The fber used in roof products is glass fber alone, whereas siding and trim board products are primarily wood fber. The material is formed with a smooth or textured surface, cut to standard sizes of panels, boards, or shingles, and cured in an autoclave. Roofng material has integral color, but board and siding products are produced with a primer, if not fully factory fnished. Most siding and trim boards are embossed with a wood grain on one surface and are smooth on the other, the smooth side being the appropriate surface to imitate planed wood.

PROPERTIES:

- Products are minimally orthotropic
- Heavier and more brittle than wood, limiting available lengths
- Very little thermal- and no moisture-driven movement
- Low water absorption, but not recommended for ground or roof contact
- Class A fame spread
- Resists insect damage
- Available in limited thicknesses and widths
- Not machinable, but may be cut with special carbide blades; cutting requires dust collection and personal protective equipment
- Cut edges require sealing
- Available unfnished, primed, or prefnished, and must be painted (with latex paint)
- 15-year limited warranty typical



Figure 21. A mineral polymer composite siding was available in the profle very similar to the historic siding. The replacement siding was used where the original material was almost completely missing beneath a more modern covering. Areas where the original wood was largely intact were replaced with matching wood to sustain more of the material integrity of the building. Photo: Belk Architecture.

Mineral / Polymer Composite

MATERIAL: Calcium carbonate or fy ash are mineral ingredients held in a matrix of various polymers to produce materials formed or molded into a number of building products. Additives found in some of the roofing products include pigments and UV stabilizers. Some use a substantial portion of recycled material. Different combinations yield products with different properties, each formulated for a specifc building component. When the material is fy ash with some glass fbers bound in a matrix of polyurethane, it is identifed as polyash. Siding, trim, bead board, and deck products are primed or prefnished, whereas roof products have integral color.

PROPERTIES:

Fly ash (siding and trim)

- Isotropic
- Heavier and more brittle than wood, and lacking structural capacity
- Little thermal or moisture-driven movement
- Suffciently low water absorption to permit ground contact
- Class C fame spread
- Resists insect damage
- Available in limited thicknesses and widths
- Machinable with carbide tools blades; requires dust collection
- Cut edges do not require sealing
- Must be painted
- 30-year limited warranty typical

Calcium carbonate or recycled rubber (roofng)

- Isotropic
- More thermally-driven movement than slate or wood
- Little to no moisture absorption
- As shingles: lighter and more fexible than slate
- As tongue-and-groove decking: heavier and harder than wood
- Not vulnerable to insect damage
- Available in limited dimensions
- As shingles: Class 4 impact resistance, and fame spread ratings ranging from Class A to Class C depending on the specifc product
- As shingles: integral color, that may be subject to fading
- As tongue-and-groove decking: prefnished with non-renewable fnish, and can be cut with woodworking tools
- 50-year limited warranties on roofng products typical

Cellulose Fiber / Polymer Composite

MATERIAL: Wood strands or fbers are coated with resin for moisture resistance and zinc-borate for insect and fungal-decay resistance, then consolidated under heated pressure. Solid composite core boards are cut from sheets of material, then factory-primed or fnished. Resulting siding and trim board products can be referred to as engineered wood, fber board, or hardboard. Products may be embossed with a wood grain or have a smooth fnish, the smooth side being the appropriate surface to imitate planed wood. Siding, trim, and tongue-and-grove decking with a slightly different properties are produced by extruding polyvinyl chloride (PVC) combined with non-wood cellulose. Roofng shingles are molded from fne wood fbers, color additives, and UV stabilizers bound with polypropylene or polyethylene (thermoplastics).



Figure 22. A porch was reconstructed using posts fabricated on site from a smooth-surface cellulose/polymer composite material. Though the face of the posts are painted, the lack of paint on the bottom at the cut ends is not consistent with manufacturers' recommendations. This treatment will allow moisture to be absorbed, shortening the life of the new replacement feature. Photo: John Sandor, NPS.

PROPERTIES:

Predominantly Cellulose (siding, trim and decking)

- Minimal thermal movement
- Resistant to moisture-driven movement
- Lighter and more fexible than solid wood, but lacks structural capacity
- Rice hull cellulose: can span typical foor-framing spacing as decking
- Low water absorption (for wood, no ground or roof contact)
- Class A or Class C fame spread
- Resists insect damage
- Available in limited dimensions
- Machinable with woodworking tools
- Wood cellulose: Cut edges must be sealed and may need additional surface prep for fnish; must be painted if unfnished or primed, also available prefnished
- Rice hull cellulose: Accepts stain/paint, but no fnish required
- 30–50 year limited warranty, depending on manufacturer

Predominantly Polymer (roofng)

- Minimal thermal movement
- Little to no moisture absorption
- Lighter and more fexible than slate
- Class 4 impact-resistance
- Class A fame spread
- Available in limited shingle size
- 50-year limited warranty typical



Figure 23. 3-D printing using various polymers is occasionally used to replicate missing metal or wood features. This new application is continually being refned, but the application can be successful when a painted, lightweight feature needs to be replicated. Photo: NPS.

Non-composite Polymers

MATERIALS: The main two polymer materials used without signifcant other components are polyurethane and polyvinyl chloride (PVC). Polyurethane millwork is constructed of urethane foam created by mixing isocyanate and resin. The polyurethane mixture is kept under pressure in a mold as it expands to any desired shape. These molded products have a closed-cell, foamed core with a denser surface skin. Polyurethane products can have exterior applications but are more often used for interior features. Polyvinyl chloride (PVC) in a solid extruded form is another polymer that can have architectural application as tongue-and-groove decking. Various polymers formed using 3-D printing are also being explored as replacements for painted metal or wood ornamental features.

PROPERTIES: Each of the two groupings has distinct physical properties

Urethane Foam (moldings and decorative elements)

- Lightweight and fexible, but lacking structural capacity
- More thermally-driven movement than wood or stone, but less than cellular PVC
- Does not absorb water
- Flammable
- Resists insect damage
- Can be cut with standard woodworking tools
- Adhesive and mechanical fasteners both recommended for installation
- Supplied primed and must be painted (latex paint)
- Lifetime limited warranty typical

Solid PVC (fooring)

- Isotropic
- Heavier and less fexible that wood
- Minimal thermal movement
- Does not absorb water
- Strength to span typical foor-framing spacing
- Impact-resistance greater than wood
- Class A fame spread
- No insect susceptibility
- Good paint adhesion, but also available prefnished
- 20-year warranty typical

Cellular Polyvinyl Chloride (PVC)

MATERIAL: Varying amounts of calcium carbonate and a foaming agent are added to melted PVC before passing through an injection die and then a calibrator to produce the shape and size of the finished product. Cellular PVC is produced as sheets, boards, and moldings. Differences in the specifics of the equipment and the rate of cooling create two varieties of product, with distinct properties. One is known as free-foam, having a fairly consistent structure throughout its section, and the other is identified as Celuka, having a skin that is denser than its core. This primarily affects the ease with which the product can be milled and shaped. The material is white and needs no applied finish. When produced for decking the material has a colored and textured wear layer over the PVC core.

PROPERTIES

- Isotropic
- Lighter and more flexible than wood
- Less strong than wood (in tension and shear), but can span typical floor- framing spacing as decking
- More impact-resistance than wood
- Negligible water absorption; no moisture-driven movement, unlike wood
- Subject to thermal expansion and contraction significantly greater than wood, though the thermal movement is less for the same dimension than the cross-grain moisture-driven movement of wood
- For longer pieces, thermal movement requires manufacturer's specifications to be followed for attachment, and inclusion of expansion joints when installed at low temperature (joints should be glued)
- Class A flame spread
- Resists insect damage
- Machinable with woodworking tools, though cut edges may need additional surface prep for finish
- Good paint adhesion; if painted, high light reflectance (HLV) is recommended to minimize heat driven expansion
- 25–30-year limited warranty, depending on manufacturer



Figure 24. Cellular PVC when painted can be used to replace deteriorated wood features. This beadboard set in a wood frame was not historically designed to shed water effectively and had deteriorated. Cellular PVC was able to match the appearance of the wood details, while its properties were well matched to the shady location, painted finish, and limited size and configuration within the overall assembly; thus, it should provide a long-lasting solution for this application. Photo: Jennifer Balson Alvarez, NPS.

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